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In April Radio Set SCR-268-T3 was service-tested by the Coast Artillery Board, showing results that were most satisfactory. As a result of the test, further work was discontinued on both Radio Sets SCR-268-T2 and SCR-268-T4. Drawings and specifications covering Radio Set SCR-268-T3 were prepared in June, and bids were requested for various of the components to be constructed by industry. Eighteen of these sets were to be built by the Laboratories for training purposes, the money to come from fiscal year 1940 funds. The eighteen sets were to furnish alant range but not altitude. In December one Radio Set SCR-268-T3 was completed, the first unit resulting from group procurement of short-range equipment.

Arrangements were made with the General Electric Company in November to install an amplidyne drive mechanism on one of the Radio Sets SCR-268-T3. This drive would move the antenna by a system of manually controlled electric motors. It was proposed to test this drive to determine whether or not the improved accuracy and decreased operator fatigue would be great enough to warrant the increased complication and expense resulting from its use.

Radio Set SCR-268 Standardized

The Signal Corps Technical Committee in July classified Radio Set SCR-268-T3 as Radio Set SCR-268, required type, adopted type, standard article, with classification as secret. At the same time Radio Set SCR-268-T1 was reclassified as obsolete. Some components varying from those of Radio Set SCR-268-T3 were incorporated into this standardized Radio Set SCR-268. The most important of these variations was the

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transmitter, which employed sixteen rather than eight of the special double-ended Mimax 100 TS tubes.

Specifications were written and bids requested for the procurement of Radio Set SCR-268 in quantity production. These sets were to furnish altitude but not slant range.

#### Further Long-Range Development

Throughout 1940 work also progressed rapidly on long-range equipment. The preceeding year had seen the beginning of these sets, essentially the same equipment in so far as components and performance were concerned. The main difference was in the type of installation, Radio Set SCR-270 being a mobile unit and Radio Set SCR-271 a fixed unit.

Late in 1939 a contract had been placed with the Blaw-Knox Company for the development of a fixed station mount to take the place of Trailer K-22 for Radio Set SCR-271. This mount was received in January 1940, and installation of radio and accessory equipment on this experimental set was begun at Twin Lights. Some of the components had to be "borrowed" from Radio Set SCR-270-T1, Serial No. 2, which had been successfully service-tested late in 1939. During February and March the fixed station was put into operation, carefully tuned, and given preliminary tests in preparation for service-testing.

In April and May Radio Set SCR-271 was service-tested by the Signal Corps Board. As a result of this test two of the fixed antenna mounts, Trailers K-22, were ordered for installation in Panama. Because



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of the fact that it was possible to install permanently all the components of this fixed Radio Set SCR-271, its performance seemed to be somewhat better during service-testing than that of the mobile Radio Set SCR-270. The report of the Board recommended standardization of the equipment with minor modifications.

Two Long-Range Radio Sets Shipped to Panama

The modifications having been made on Radio Set SCR-271, upon completion of the antenna towers two sets were shipped to Panama. The materials for the towers and buildings were shipped by the Blaw-Knox Company, and a representative of that company went to Panama to supervise the installation. Two engineers went from the Laboratories to supervise the installation of the sets and the adjustment of the radio equipment. One of the sets was installed at Fort Sherman on the Atlantic Ocean, the other on Taboga Island on the Pacific.

Since the mobile Radio Set SCR-270-T1, Serial No. 2, was to be turned over to troops early in the year, immediate attention was given to obtaining duplicate components to take the place of those removed from this set for installation on the service-test model of Radio Set SCR-271. Further tests of the 165 mc portion of this mobile set had to be abandoned, and the 165 mc antenna was removed.

Of the two Radio Sets SCR-270-T1, Serial No. 1, which had been service-tested by the Signal Corps Board in November 1939, one was sent to Panama for training purposes in the Signal Corps Aircraft Warning Service. Two Radio Sets SCR-270 were ready for formal delivery to troops by

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March, and six more were to be procured.

In the summer of 1940 Radio Sets SCR-270-T1, Serial Nos. 1 and 2, were used in connection with the First Army Maneuvers in the vicinity of Watertown, New York. Standard transportation for these two sets was received in August, and after their return from Watertown the two sets were reinstalled on their trailers. Both sets were later turned over to the First Aircraft Warning Company.

Additional sets, varying somewhat from Radio Set SCR-270-T1 in the design of certain of the components, were constructed at the Laboratories. These sets were designated as Radio Sets SCR-270-A. Five more of them were procured from the Westinghouse Electric and Manufacturing Company during the year, the first group procurement of long-range equipment.

Experimental work was continued on SCR-270-A, resulting in Radio Set SCR-270-B, which differed considerably from either of the other two types. Funds for further procurement being available, a contract was awarded for the procurement of these long-range units. Radio Set SCR-271 as being procured, did not include operating rooms, antenna towers or power supply equipment.

#### Efforts Made to Eliminate Need for Spark Gap

Toward the end of the year experimentation was under way in an effort to eliminate the spark gap from all long-range sets. One possibility being investigated was that of using a beam-deflection tube as the first stage in the receiver. Another method under consideration was through the use of special diodes developed by the General

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Electric Company. An effort also was made to develop a mechanical means of shorting the receiver input during the time that the transmitter was in operation. Although this work was almost continuous, no really satisfactory results had been obtained by the end of the year.

Attention Given to Marine Surface Craft Detection

During 1940 attention was turned toward the development of equipment that would serve satisfactorily in the detection and tracking of marine surface craft. The military purposes of this equipment were that it should detect the presence of such craft by the radiation of either heat or radio waves and that it should indicate the range and direction of the located craft with respect to the detector or some other designated reference point. It also was essential for it to have certain other qualities. Among these it was desired that the equipment give direction and range up to 10,000 yards under all atmospheric conditions and up to 40,000 yards under average atmospheric conditions, night or day; that it begin to furnish data immediately; and that it be of a design for ready installation in a detached position without forming a conspicuous target.

In September an experiment was made on detecting surface craft with equipment developed for the purpose of tracking radio meteorographs. Tests of this equipment indicated that a large vessel might be tracked with it to a range of approximately 24,000 yards, but the results were not considered conclusive because of the limited duration of the tests.

In December 1940 a 600 mc detector set from the Western Electric

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Company was tested against Marine Surface Craft by the Navy Department at Highlands, New Jersey. The Signal Corps Laboratories furnished the necessary ship-to-short communications during these tests. The set seemed promising equipment for use as a marine surface craft detector, and a service-test model was ordered from the Bell Telephone Laboratories for installation at Navesink Light to determine its suitability for this use. The date for delivery of this unit was first set as May 1941, but in October the Bell Telephone Laboratories said that they expected to be able to deliver it by January.

#### Experimental Work Continues

Besides the development work done during the year on radio sets, there was also considerable activity in experimental work on other radio equipment.

Equipment was designed to accomplish range measurements by shifting the oscilloscope picture across the screen by means of a phase shifter so that range could be read as a fraction of one cycle (one cycle corresponding to a definite number of yards). Two types of phase shifter were employed. The first consisted of a resistance bridge device arranged with resistance steps sufficiently small to permit reading the range to 100 yards. The accuracy of this apparatus was determined by a large number of resistors (in this case 410). Any inequality in resistors would cause erroneous readings of range. This device, although practical, was too expensive to manufacture, and it caused considerable trouble because of contact resistance.

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## SCOPE

The other phase shifter developed employed a pickup coil that rotated in a magnetic field in such a way as to permit selecting any fraction of one complete cycle. The dial of this unit was calibrated directly in yards and could transmit data through Selsyn circuits to any desired point. This unit was much smaller, cheaper, and less subject to trouble than the resistor-type phase shifter, and it was therefore incorporated in both short-range and long-range equipment.

Some attention was given to frequencies in the 30 to 60 mc band. For experimental purposes two low-frequency pulse transmitting and receiving systems were ordered, one of them to be tested against aircraft in flight to determine the possible application of these low frequencies. Also some progress was made on equipment built to operate at higher frequencies.

## Continued Investigation on Higher Frequencies

Among the difficulties which had been encountered with commercial tubes operating at frequencies above 100 mc was the failing that, following the conventional tube design circuit, the leads to the various elements of the tubes passed through the envelope as close to the elements as possible. When tubes were operated for pulse work, in which the voltages were many times those normally encountered, considerable trouble was encountered because of flashovers, seal failures, and so forth. It was decided that the solution to many of these difficulties lay in so designing the tubes that the circulating current in the oscillating tank circuits did not pass through the tube envelope. A 400 mc tube was therefore designed which was essentially a complete



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push-pull oscillator inclosed in an envelope. This tube behaved satisfactorily, and a contract was signed with the Western Electric Company for its production.

In addition to the equipment being experimented with at 400 mc, contracts were awarded for tubes to operate at 600 mc and 1200 mc. Because of the pressing nature of other work, relative to the service-testing of sets already built and given preliminary tests, activity was limited on equipment to operate at these higher frequencies.

Plans were formulated during December, however, for the construction of a service-test model of the short-range Radio Set SCR-268 to operate at 600 mc. Many of the components for such a set were already on hand or on order, including keyers, rectifiers, antenna mounts, oscilloscopes, range-conversion units, power units, and data-transmission systems. The essential components still to be constructed were the antenna switching mechanism, the transmitter, the receiver, and the antennas.

#### A New Project Initiated

Just at the close of the year a new project was initiated for development by the Radio Position Finding Section. This project called for the development of equipment for determining the altitude of approaching aircraft over water at less than 50 miles range for the use of pursuit aviators. A request was made of the General Electric Company to submit a quotation on taking over all or a part of the development incident to this project.

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British Equipment Discussed and Examined

Toward the close of 1940 representatives of the Signal Corps Laboratories were given a demonstration of the British GL-1 detection equipment in use at Halifax, Nova Scotia. According to the report of representatives, there seemed to be little in the demonstrated British apparatus that would warrant inclusion in the equipment being developed by the Signal Corps Laboratories. However, three novel features were thought to be worth investigating: namely, (1) the use of potentiometer as a range-measuring device; (2) the addition of an r-c circuit to the normal grid keyer in order to narrow and improve the shape of the transmitted pulse; and (3) the use of a single switch which would permit quickly extending or narrowing the picture as seen on the range oscilloscope without any shift of that portion of the picture occurring behind the range cross wire.

The Laboratories' representatives also examined a fixed-beam, radio-echo, surface-craft detector of Canadian design that was installed at the mouth of the harbor. The range and direction furnished by this equipment seemed sufficiently good for accurate barrage fire, but it appeared that it was being used only for intelligence purposes. This apparatus was simple, well-constructed, and cheap.

Certain other British equipment was proposed for procurement, including direction-finder equipment; airborne detection equipments; and various types of tubes, fuse bombs, and rockets.

Another group of representatives from the Laboratories visited

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Ottawa in December 1940 for discussions with British and Canadian officials on their equipment. Procurement of the Canadian Night Watchman was the main purpose of this visit, but discussions covered some of the other British equipment as well. The discussions were felt to be relatively unsatisfactory, since the officials seemed to disagree to a great extent on the functions and potentialities of the equipment under discussion. However, the real purpose of the visit was accomplished with the promise of delivery of a Canadian Night Watchman to the Signal Corps Laboratories by the end of February 1941.

#### VII. NEW FIELDS OPENED UP IN 1941

Throughout 1941 the development work of the Laboratories grew by leaps and bounds. All the information possible was obtained on every sidelight, and starting right out with January an unusually large number of contracts were entered into for production of various types of equipment. Unlike a large number of the contracts awarded previously, these contracts were given for specific development projects. The great strides forward had resulted in so many different possibilities for radio equipment that the manufacturers were taxed to the limit to develop and construct equipment mainly according to specifications provided by the Laboratories.

It was obvious from the total number of sets on order from fiscal year 1941 funds that the work of the Signal Corps Laboratories was proceeding on a constantly increasing scale. Experimentation

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resulted in many improvements that were incorporated in the sets, and it also showed possibilities for the development of other equipment to furnish instantaneously even more complete and accurate data.

#### Plan Position Indicator Developed

Of particular interest among the many developments during the year was the circular-sweep oscilloscope, also known as a plan-position or panoramic indicator. Some experiments had already been carried out, but the first real step was taken in February 1941 when the Colonial Radio Corporation was asked for a quotation on developing such an oscilloscope. This oscilloscope was to indicate the presence of a target by a bright spot on the face of the screen. The system was to be so arranged that the position of the spot with respect to the center of the screen would show both the distance and the direction of the target.

In April a quotation was requested of the General Electric Company for its long-persistence type of tube. It was hoped that, through the use of such a tube in the circular-sweep oscilloscope, the screen would present a complete picture of the area being covered, with bright spots showing all the targets within range at any instant. This tube was also to be tested to determine the desirability of long persistency in standard Signal Corps oscilloscopes.

In April a contract was signed with the Colonial Radio Corporation, and the oscilloscope was received in August. The plan

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was to test it with various sets to determine the possible application of this type of indication to both existing and development sets. The oscilloscope performed according to expectations, and in October requisitions were written for the purchase of ten oscilloscopes with a keying rate of 1367 cycles and ten more with a keying rate of 200 cycles.

Another contract had been awarded to the RCA Manufacturing Company for the development of a combined circular-sweep oscilloscope and data-transmission system. This combination also was received in August, and it tested so satisfactorily that a contract was signed with the RCA Manufacturing Company in December for ten more of these units.

During the year electrostatic methods of deflection also were experimented with for use on panoramic oscilloscopes. Two special radial deflection oscilloscopes were ordered from the RCA Manufacturing Company, but the tests proved these oscilloscopes to be unsatisfactory and this development was discontinued.

Fire Destroyed Receiver Development Equipment

A setback to the Laboratories development work occurred during March 1941, when antenna shelter No. 2 at Fort Hancock was completely destroyed by fire. This shelter housed practically all the receiver development work of the Radio Position Finding Section. The fire resulted in the destruction of certain partly finished development equipment and a considerable amount of test apparatus.

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Fortunately no records or drawings of any consequence were destroyed since, a short time before, these had been transferred to a fireproof metal shelter.

#### Coordinating with Other Agencies

A suggestion was forwarded to officials of the Signal Corps that steps be taken to obtain a working coordination with other branches in the design of new equipment. The particular instance under criticism was that a new helmet had been standardized without regard to the design of the earphones in use at the time. It was suggested that some means be developed whereby military characteristics for items developed by other branches which influenced radio equipment should be made to include adequate requirements for use by radio.

The Laboratories themselves were coordinating on specifications with some agencies. One instance of this coordination was seen in the conference between representatives of the Laboratories and of the Bureau of Ships of the Navy Department, when standardization of various oscilloscope tubes was considered.

#### Belmar Area Acquired

The procurement of the King's College grounds at Belmar, New Jersey, gave a new impetus to the development work, since it made available further suitable installation sites for much equipment. Since there already were in existence some buildings in this area, it was planned first to recondition these and then to build others

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necessary for this new Signal Corps Field Laboratory.

By October two 50-foot towers and one 30-foot tower had been installed in the new Belmar Area, and progress was being made on the reconditioning of the buildings.

#### Patent Investigations

Of considerable concern to the Signal Corps Laboratories during the year was the subject of patents. In August an investigation of inventions submitted by outside agencies revealed that some inventions thought to be original with the Laboratories had been developed independently by others. This investigation was continued with a view toward securing priority for the Radio Position Finding Section on those developments useful in aircraft-position-finding work.

Also certain patent applications pending in the United States Patent Office were investigated to determine any place they might have in the past, present, and possibly future developments of the Radio Position Finding Section.

#### Closer Cooperation with British and Canadians

Toward the close of 1940 an increasing cooperation had been apparent among the British, Canadians, and Americans on the various types of equipment for the detecting and tracking of aircraft and marine craft under differing conditions and varying distances.

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Delivery of the Canadian Night Watchman that had been promised to the Signal Corps Laboratories by the end of February 1941 was delayed, and the unit was not received until July. Considerable attention was given to a study of this equipment when it arrived, but it was not until the close of 1941 that a contract for its installation, engineering, and life testing was in preparation.

Meanwhile a similar unit, Radio Set SCR-541, was constructed by the Westinghouse Electric and Manufacturing Company. This unit was a searchlight controller operating on the frequency band of 2,900 to 3,100 mc and capable of locating aircraft at a range of 15,000 yards with an accuracy of  $\pm 1^\circ$ .

Certain combinations of this set with others were under consideration. In October the Westinghouse Electric and Manufacturing Company was asked to consider the production of a combination of Radio Set SCR-541 with the GL-3 unit when and if the accuracy requirements were relaxed. Specifications were in preparation in November for a combination of Radio Set SCR-541 with Radio Set SCR-533, a ground unit for the interrogation of planes. Some consideration also was given to the feasibility of combining Radio Set SCR-541 directly with the searchlight. Meanwhile the Westinghouse Electric and Manufacturing Company was authorized to proceed with the production of Radio Set SCR-541 itself.

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Similar to Radio Set SCR-541 was Radio Set SCR-571, except that this set operated at a frequency of 10 cm. In addition, the use of several other frequencies was possible. Although the performance of this set was up to expectations, it was decided to do no further work on it because of the satisfactory operation of Radio Set SCR-541.

With a view to producing results equal to the Canadian Gun Laying Equipment GL-3, the General Electric Company constructed Radio Set SCR-545. The Canadian GL-3 equipment consisted of two main components: an accurate position finder and a zone position indicator, or "Early Warning" equipment. The American unit was completely mobile and had an accurate tracking range of 24,000 yards. It supplied data directly to an antiaircraft gun battery.

The Canadian GL-3 equipment was tested by the Coast Artillery Board, and the Laboratories asked the Board for a copy of its report.

In August the Signal Corps Laboratories were designated as the inspection agency for 400 Canadian GL-3 radio sets to be procured from Research Enterprises Limited in Canada. Deliveries were expected to be begun in September; and by October it was thought that four units would be ready for test.

Certain inspection problems were under investigation, and

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